ELECTRONICS & COMMUNICATION ENGINEERING DEPARTMENT

THAPAR INSTITUTE OF ENGINEERING & TECHNOLOGY

END SEMESTER EXAMINATION (DECEMBER-2006)

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CN-006 CDMA & GSM SYSTEM M.MARKS: 45

NOTE: (i) ATTEMPT ALL QUESTIONS FROM PART A
(ii) ATTEMPT ANY FIVE QUESTIONS FROM PART B
(iii) PART 'A' SHOULD BE ATTEMPED FIRST
(iv) SUDENTS ARE ALLOWED USING ERLANG TABLES
(v) RETURN ERLANG TABLES WITH ANSWER SHEETS

PART A

Q1. A radio signal with bandwidth W_s and data rate $1/T_s$ is transmitted over multipath fading channel having a maximum delay spread of T_m and a coherence bandwidth of T_D. Define a condition for which the channel can be considered as frequency non selective slowly fading. (1)

Q2. Explain the difference between selection diversity combining and maximal ratio combining in a diversity system. (1)

Q3. A radio signal with bandwidth of 5 MHz is transmitted over a multipath fading channel having a coherence bandwidth of 40 MHz. Characterize the channel and justify your answer. (1)

Q4. Give a brief description of FDD duplexing principle and TDD duplexing principle and explain the difference between them. (1)

Q5. Determine the necessary E_b/N_0 to detect BPSK with an average bit error probability of 10^{-5} for (a) a Gaussian Channel (b) Rayleigh fading Channel (2)

Q6. In IS-95 communication system the chip rate is 1.2288 Mchips/sec and the bit rate is 9.6 kbps/sec. If the E_b/N_0 is 6.8 dB, what is the average number of the users in the system? (2)

Q7 Once a physicist Robert Wood did not stop his car behind the red traffic light. He excuses himself by using Doppler Effect. Because of Doppler shift the red light had turned to the green one. How quickly he had to move in order his claim to be true. Red light has wavelength of 630 nm and green light has a wavelength of 560 nm. (2)

Q8. Calculate the necessary frequency separation between two carriers such that the maximum normalized amplitude correlation is 0.3.The delay spread of the channel is 3 μs. (1)

Q9. In GSM paging can be implemented using TMSI or IMSI. Why it is preferable to use TMSI? (2)

Q10. GSM channel rate is 270.33kbps. The user bit rate is 13 kbps. Give reason why the channel speed is not 13x8kbps=104kbps. (2)

PART B

Q1. (a) Consider a cellular system with hexagonal geometry. Let R be the radius of the cell and D be the distance to the center of the nearest co-channel cell (i.e., the nearest cell that re-uses the same frequency channels). Prove that the co-channel reuse ratio, Q =D/R, is given by Q= $\sqrt{3N}$, where N is the number of cells per cluster. (2)

(b) What are Fresnel zones and what is the significance of 0.6 FFZ clearance? Derive an expression for the radius of n^{th} Fresnel zone. (4)

Q2. (a) Consider a cellular system with 420 full duplex channels and a 7-cell reuse pattern so that each cell is allocated 60 channels. Assume the system has been designed so that at peak traffic intensity, the blocking probability is 1%.

(i) What is the peak traffic intensity (in Erlangs/cell) that can be supported with this system? What is the SIR assuming propagation exponents of n= 3,4,5?

(ii) It is proposed to improve the signal-to-interference ratio by employing 120-degree antenna sectoring as described in the text. Since there are three sectors per cell, each sector will now have 20 channels. What is the peak traffic intensity per sector and per cell that can be supported by this system? What is the SIR assuming propagation exponents of n= 3,4,5? (2, 2)

(b) Find the capacity of a DS-CDMA system containing K users. It is given that system is interference limited rather than noise limited. (2)

Q3. (a) Show that the magnitude (envelope) of a zero-mean complex Gaussian random variable, for which the real and imaginary parts are independent and have equal variances, has a Rayleigh probability density function. (3)

(b) Discuss selection diversity in detail and show that average SNR improvement by M branch selection diversity combiner is $\sum_{k=1}^{M}\frac{1}{k}$ (3)

Q4. (a) The signal component of a coherent PSK system is defined by

$$S(t) = A_c\, k\, \mathrm{Sin}(2\pi f_c t) \pm A_c \sqrt{1-k^2}\ \mathrm{Cos}(2\pi f_c t)$$

Where $0 \le t \le T_b$, and the plus sign corresponds to symbol 1 and minus sign correspond to symbol 0. The first term represents a carrier component included for the purpose of synchronizing the receiver with the transmitter. Show that in the presence of Additive white Gaussian noise of zero mean power spectral density $N_0/2$, the average probability of error is given by $P_e = \frac{1}{2}\mathrm{erfc}\left(\sqrt{\frac{E_b}{N_0}(1-k^2)}\right)$ where $E_b = \frac{1}{2}A_c^2 T_b$ (3)

(b) In a cellular system the average call duration is 2 minutes and a user uses his mobile for an average once per hour. Assume that the total number of traffic channels in the system is 399 and a frequency reuse factor of 7. calculate maximum offered traffic and the maximum number of subscribers per cell for a blocking probability of 1% when

I. cells are not sectorized

II. each cell has three sectors

III. each cell has six sectors

IV. Comment upon the result (3)

Q5. (a) A source emits three equi-probable messages m_1, m_2, m_3 encoded by $S_1(t)$, $S_2(t)$, $S_3(t)$ respectively where

$$S_1(t) = 20\sqrt{2}Sin(\frac{2\pi}{T_M}t) \qquad S_2(t) = 10\sqrt{2}Cos(\frac{2\pi}{T_M}t) \qquad S_3(t) = -10\sqrt{2}Cos(\frac{2\pi}{T_M}t)$$

and $T_M = \frac{1}{20}$

Each of these signal duration is $0 \le t \le T_M$ and is zero outside this interval. The signals are transmitted over AWGN channel.

i) Determine the basis functions

ii) Draw the signal constellation diagram.

iii) Determine decision regions. (3)

(b) A binary signal is to be transmitted from Patiala to Rajpura using wireless RF channel at a rate of 1000 bits/sec. Assume detector bandwidth of B=2/T and $A^2 >> N_0$. If the noise PSD is $\frac{N_0}{2} = 10^{-13}$ watt per hertz and bit error probability $P_b = 10^{-5}$.

(a) What is amplitude of signal if coherent BFSK is used?

(b) What is average power required if BPSK is used?

(c) What is average energy required per bit required for given BER if QPSK is used? (3)

Q6. (a) Discuss DS-CDMA standard with block diagrams of various channels in forward link and reverse link. Also explain the use of various PN sequences in these channels.

(b) A cellular system uses a 4 cell frequency re-use pattern. By approximately what factor will the use of 120 degree sectoring increase the signal-to-co-channel interference ratio, S/I? (6)

Appendix 1.1
Blocked-Calls-Cleared (Erlang *B*)

	A, erlangs												
	B												
N	1.0%	1.2%	1.5%	2%	3%	5%	7%	10%	15%	20%	30%	40%	50%
1	.0101	.0121	.0152	.0204	.0309	.0526	.0753	.111	.176	.250	.429	.667	1.00
2	.153	.168	.190	.223	.282	.381	.470	.595	.796	1.00	1.45	2.00	2.73
3	.455	.489	.535	.602	.715	.899	1.06	1.27	1.60	1.93	2.63	3.48	4.59
4	.869	.922	.992	1.09	1.26	1.52	1.75	2.05	2.50	2.95	3.99	5.02	6.50
5	1.36	1.43	1.52	1.66	1.88	2.22	2.50	2.88	3.45	4.01	5.19	6.60	8.44
6	1.91	2.00	2.11	2.28	2.54	2.96	3.30	3.76	4.44	5.11	6.51	8.19	10.4
7	2.50	2.60	2.74	2.94	3.25	3.74	4.14	4.67	5.46	6.23	7.86	9.80	12.4
8	3.13	3.25	3.40	3.63	3.99	4.54	5.00	5.60	6.50	7.37	9.21	11.4	14.3
9	3.78	3.92	4.09	4.34	4.75	5.37	5.88	6.55	7.55	8.52	10.6	13.0	16.3
10	4.46	4.61	4.81	5.08	5.53	6.22	6.78	7.51	8.62	9.68	12.0	14.7	18.3
11	5.16	5.32	5.54	5.84	6.33	7.08	7.69	8.49	9.69	10.9	13.3	16.3	20.3
12	5.88	6.05	6.29	6.61	7.14	7.95	8.61	9.47	10.8	12.0	14.7	18.0	22.2
13	6.61	6.80	7.05	7.40	7.97	8.83	9.54	10.5	11.9	13.2	16.1	19.6	24.2
14	7.35	7.56	7.82	8.20	8.80	9.73	10.5	11.5	13.0	14.4	17.5	21.2	26.2
15	8.11	8.33	8.61	9.01	9.65	10.6	11.4	12.5	14.1	15.6	18.9	22.9	28.2
16	8.88	9.11	9.41	9.83	10.5	11.5	12.4	13.5	15.2	16.8	20.3	24.5	30.2
17	9.65	9.89	10.2	10.7	11.4	12.5	13.4	14.5	16.3	18.0	21.7	26.2	32.2
18	10.4	10.7	11.0	11.5	12.2	13.4	14.3	15.5	17.4	19.2	23.1	27.8	34.2
19	11.2	11.5	11.8	12.3	13.1	14.3	15.3	16.6	18.5	20.4	24.5	29.5	36.2
20	12.0	12.3	12.7	13.2	14.0	15.2	16.3	17.6	19.6	21.6	25.9	31.2	38.2
21	12.8	13.1	13.5	14.0	14.9	16.2	17.3	18.7	20.8	22.8	27.3	32.8	40.2
22	13.7	14.0	14.3	14.9	15.8	17.1	18.2	19.7	21.9	24.1	28.7	34.5	42.1
23	14.5	14.8	15.2	15.8	16.7	18.1	19.2	20.7	23.0	25.3	30.1	36.1	44.1
24	15.3	15.6	16.0	16.6	17.6	19.0	20.2	21.8	24.2	26.5	31.6	37.8	46.1
25	16.1	16.5	16.9	17.5	18.5	20.0	21.2	22.8	25.3	27.7	33.0	39.4	48.1
26	17.0	17.3	17.8	18.4	19.4	20.9	22.2	23.9	26.4	28.9	34.4	41.1	50.1
27	17.8	18.2	18.6	19.3	20.3	21.9	23.2	24.9	27.6	30.2	35.8	42.8	52.1
28	18.6	19.0	19.5	20.2	21.2	22.9	24.2	26.0	28.7	31.4	37.2	44.4	54.1
29	19.5	19.9	20.4	21.0	22.1	23.8	25.2	27.1	29.9	32.6	38.6	46.1	56.1
30	20.3	20.7	21.2	21.9	23.1	24.8	26.2	28.1	31.0	33.8	40.0	47.7	58.1
31	21.2	21.6	22.1	22.8	24.0	25.8	27.2	29.2	32.1	35.1	41.5	49.4	60.1
32	22.0	22.5	23.0	23.7	24.9	26.7	28.2	30.2	33.3	36.3	42.9	51.1	62.1
33	22.9	23.3	23.9	24.6	25.8	27.7	29.3	31.3	34.4	37.5	44.3	52.7	64.1
34	23.8	24.2	24.8	25.5	26.8	28.7	30.3	32.4	35.6	38.8	45.7	54.4	66.1
35	24.6	25.1	25.6	26.4	27.7	29.7	31.3	33.4	36.7	40.0	47.1	56.0	68.1
36	25.5	26.0	26.5	27.3	28.6	30.7	32.3	34.5	37.9	41.2	48.6	57.7	70.1
37	26.4	26.8	27.4	28.3	29.6	31.6	33.3	35.6	39.0	42.4	50.0	59.4	72.1
38	27.3	27.7	28.3	29.2	30.5	32.6	34.4	36.6	40.2	43.7	51.4	61.1	74.1
39	28.1	28.6	29.2	30.1	31.5	33.6	35.4	37.7	41.3	44.9	52.8	62.8	76.1
40	29.0	29.5	30.1	31.0	32.4	34.6	36.4	38.8	42.5	46.1	54.2	64.5	78.1